Throw away the clay as modelling goes digital

FreeForm modelling system with Phantom interface

Compared with the tools it replaces - clay, wax, foam and wood or traditional 3D solids or surface modelling software - incorporating a system known as FreeForm modelling into product design and development could provide significant benefits to many companies, especially in the athletic or casual footwear sectors. In essence, the programme offers

- dramatic reduction in product development time
- design quality improvement
- reduction in design and manufacturing costs

The system transforms the way products are developed. By combining a touch enabled interface to a digital modelling tool, users can quickly create complex forms, previously only possible by hand. These digital forms can be used directly in standard downstream processes, such as rapid prototyping, tooling design and CNC machining, to dramatically reduce time-to-market. Using FreeForm and its Phantom touch interface, modellers literally feel the material yield as they cut, smooth and blend features into the exact form envisioned, with an ease and control not possible without touch. Controlling sculpting, wire cutting and similar tools via touch ensures direct connection to the model.

System workflow & benefits - athletic footwear

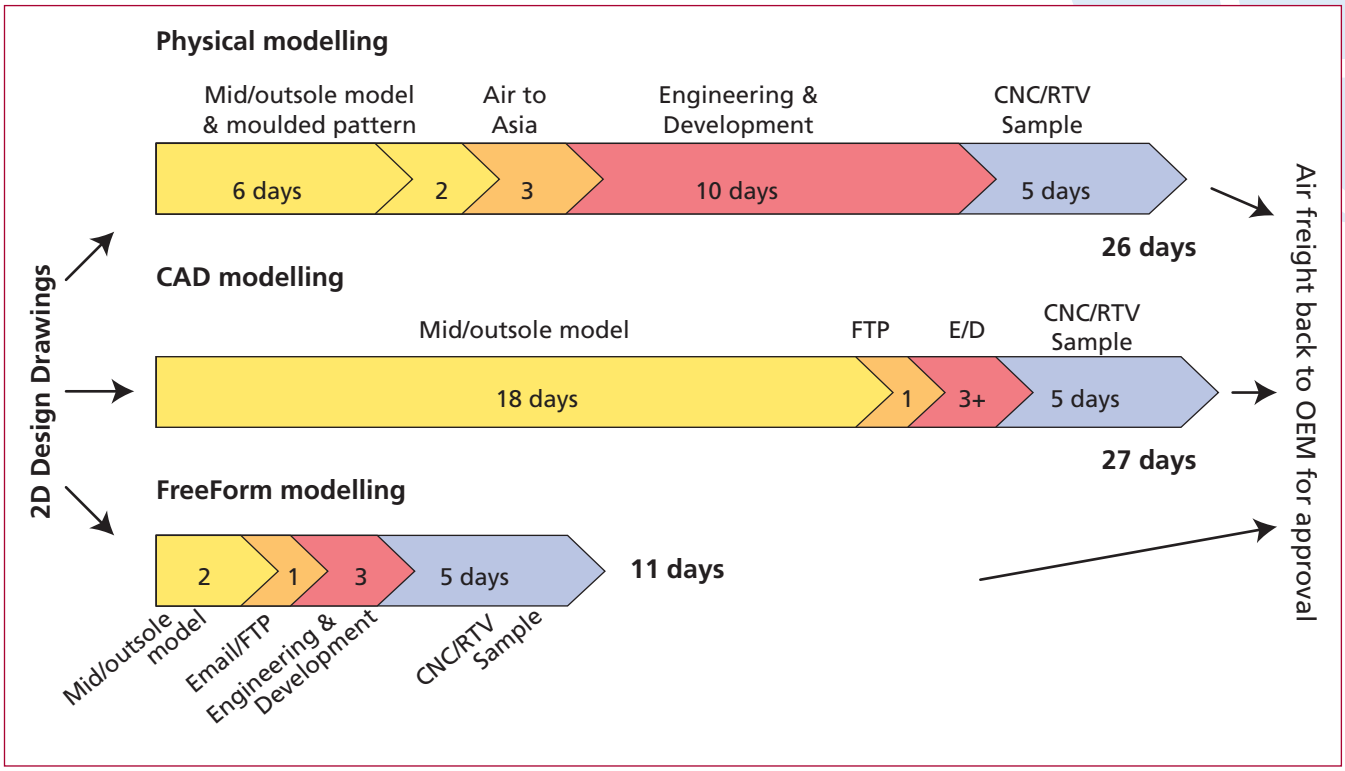
Success in the athletic footwear business is largely driven by styling and design. Yet being cost competitive frequently requires efficient use of offshore production partners. Balancing these elements is difficult for both brand OEMs and the manufacturers they work with. Most firms use clay to turn 2D drawings into physical models that can be iterated, approved and passed downstream for production. A number have also begun to use 3D CAD software to create midsole/outsole models for some designs. FreeForm has managed to establish itself at both ends of the development pipeline, as an alternative way to cut cycle time and reduce costs, while staying true to the intended design.

When creating initial 3D midsole/outsole models, the system can be significantly more productive than either physical tools or solids/surface modelling software. On average, it is said to be 65% more productive than physical modelling, and up to 90% more so than 3D CAD. This enhanced productivity can reduce average cycle times in turning 2D design drawings into production samples from 26 days for physical and 27 days for 3D CAD processes, to just 11.

The chart compares development times for three types of modelling workflow - physical, CAD, and FreeForm. The data used is from a variety of OEMs and manufacturers, and covers numerous benchmark jobs. Individual designs vary in complexity and the more difficult obviously take longer to model and develop than the average times shown. In addition, footwear manufacturers sometimes compress cycle time by assigning multiple modellers to one project. While this reduces the number of “calendar days” needed to meet a deadline, the number of “man days” needed — and which these flowcharts show — remains the same.

As with most products, design and development starts with a marketing brief that sets design direction, cost parameters, etc. 2D design work takes four to six weeks using mostly pencil or pen on paper and/or 2D drawing programmes. Design typically produces a set of drawings depicting the approved design in top, front, and side aspects, with sectional slices also possibly included. This information is then passed to a modelling group to turn into 3D product models that can be more effectively evaluated and approved.

The first step - creating midsole/outsole models - is usually in clay. This can take from four to 14 days, averaging 6.2 modelling, and 1.5 moulding patterns from more durable materials. 3D models using 3D CAD software may take six to 25 days and average 17.5. FreeForm can cut modelling to one to four days, with an average 1.9. Its productivity advantage over clay stems from an ability to work directly from designers’ digital drawings, instant correction of mistakes, rapid resolution



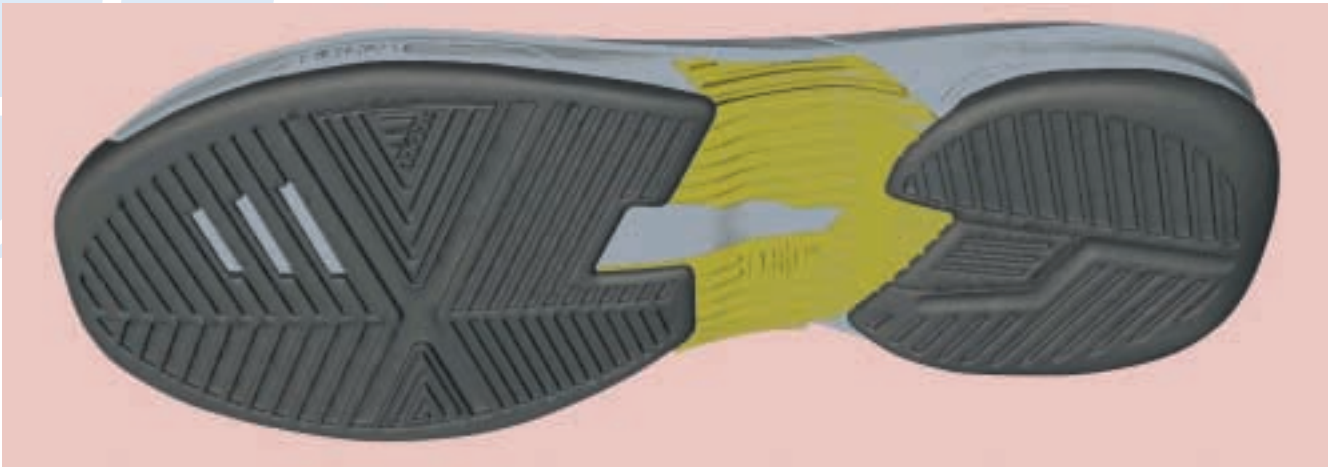
of problems via interactive iteration with designers and the use of a variety of tools for modelling grooves, tread patterns and lugs. The long modelling time for 3D CAD mainly stems from its engineering-oriented nature. Solids and surface modelling software is ideal for 'prismatic' shapes like gears, etc., and can also be used for smoothly flowing shapes on car bodies and similar projects. Modelling the textured, tightly detailed, sculptural shapes in footwear requires great user skill and training – plus plenty of time.

Once initial 3D models are finished, design communication becomes the issue. As shown in the chart, physical patterns must be shipped via airfreight. This is time consuming and costly when multiple iterations and shoe lines are involved. In contrast, both 3D CAD and FreeForm yield digital models, so files can be e-mailed or FTP'd to offshore production partners. It also enables tooling makers to work from the actual digital design data instead of recreating models from drawings or physical patterns. Loss of design intent is therefore minimised.

Once a design model is sent downstream, engineering and development work turns it into a prototype capable of being manufactured. This takes seven to 15 days and averages 10. Many manufacturers have already begun using digital tools for engineering and development, even when physical models are sent by the OEM. They start by recreating the model in CAD, which needs six to 12 days, though multiple engineers working simultaneously can reduce calendar time to three days (two to four can accomplish six to12 man days of work in three calendar days). CNC tool paths are generated from this CAD model and some initial grading may be done to check the design in other sizes but, in general, grading to all sizes is only done after production prototypes are approved. For designs following the 3D CAD workflow, the extra time spent creating the initial 3D model pays off with significantly shorter engineering and development times. Modifications can usually be made to the original digital model in a few days since there is no need to recreate it. The nature of surface and solids modelling, is such that engineering changes may sometimes be difficult or impossible, because of a model's construction history. But generally, 3D CAD modifications happen faster than with physical modelling. The CAD data is then used to generate CNC tool paths for the next step in the process.

Similarly, when final concept models are sent in FreeForm, production partners also using the system can make manufacturing-related changes to the model in one to three days. Not only is it much faster, but refining an original FreeForm model (instead of creating a new CAD model from physical prototypes and drawings) means crucial design intent is better preserved, as fewer unintentional changes are introduced. The refined model is also less likely than a remodelled one to need more time-consuming iteration between designer and manufacturer. The next step for all three work-flows is generally the same at this point; moulds are machined via CNC and from which RTV rubber sample soles are cast. This takes about five days and the samples are usually mailed back to OEMs for approval or further iteration.

The steps so far are core modelling-oriented, where 2D design sketches evolve into production prototypes. So far, FreeForm has had the broadest impact but there is more to the overall design and development process, so some athletic footwear companies also use FreeForm modelling further downstream. After initial production samples are complete, it may take several iterations between OEM and manufacturer to solve production problems consistent with intended design. With FreeForm modelling at both ends, it can be done far more quickly and accurately by working on and swapping digital files. Sharing files virtually eliminates communication delay and eliminates three days in air transport time. Designers and engineers half a world away can work together 24 hours a day



Athletic shoe sole modelled with the FreeForm system, courtesy of adidas-Salomon. The system has also attracted the attention of Nike, Reebok, Wolverine and New Balance

by turning iterations around while overseas counterparts sleep. When the time needed to machine new moulds and mould samples is also factored in (five days), eight business days of cycle time can be saved per iteration. If an average project needs two to three iterations, potential cycle time reduction using FreeForm downstream is 16 to 24 working days. Making and shipping costs for physical prototypes are also saved.

3D CAD is roughly comparable to FreeForm in these later steps. It also exploits the advantages of electronic file sharing. Model iterations can be harder to accommodate though, when the surface/solid model's construction history limits what changes can be made and how. In contrast, FreeForm's flexible modelling representation is designed to facilitate quick and easy model iteration. Examples from Taiwan and China are said to have reduced engineering effort (total hours needed) by almost 70% and cycle time (total elapsed days) for production engineering by almost 50%, compared with other tools.

Once production prototypes are approved by the OEM, manufacturers grade the model into the sizes needed for manufacture. Several leading companies do this with software that works directly from STL models exported from the FreeForm system, using both proprietary in-house tools and commercial packages. The dozen or so graded STL models are then machined from STL data, again using commercially available packages.

Given the availability of 3D CAD tools and advantages for digital collaboration they offer, why hasn't the footwear industry adopted CAD more readily? One reason has been mentioned: shoe sole designs tend to be extremely challenging for solids and surface modelling tools to capture. Design compromises must often be made in order to accommodate the needs of such maths-based modelling software. Additionally, 3D CAD has a steep, expensive learning curve and one industry executive has declared learning time to be three to six months. Even after six months or more, not all 3D CAD modellers reach an adequate proficiency level for complex soles. The cost of training, coupled with lost modeller productivity, can be far higher than the cost of the CAD software itself. FreeForm modelling appears capable of overcoming both barriers. Its flexible model representation eliminates design compromises made for the sake of the modelling tool, while intuitive touch-based modelling tools eliminate long learning curves.

System workflow and benefits - brown shoes

To a lay person, casual or brown shoes might seem more or less the same as athletic footwear. However, the details of brown shoe design and modelling differ enough from athletic footwear to warrant a separate analysis. For shoes with moulded rubber (as opposed to leather) soles, product design and development is generally the same as athletic shoes. Designers use pencil and pen or 2D drawing software to formulate design concepts that fulfil a marketing brief. Model-makers turn the drawings into 3D models, usually with wood, wax or clay. Several iterations between designers and modellers are often needed to converge on the 'right' model to be passed on to tooling and production. This physical prototype model is then usually recreated in 3D CAD software from measurements taken by hand, point digitising or cloud scanning and CAD/CAM, then used for mould making. Several firms have tried going directly to 3D CAD from design drawings, but this does not seem to offer enough downstream advantages to offset the longer time required to finish the initial prototype. Such work-flows are therefore not widespread.

As in the athletic sector, a number of leading brown shoe makers have turned to FreeForm to reduce cycle time and production costs, while maintaining design intent. Shoe soles modelled in wood or wax take two-and-a-half to four days, with an average of about 25 hours. FreeForm modelling can apparently reduce this by 50% and any additional modelling iterations, often needed to refine a design, can be done even more quickly and productively.

Brown shoe manufacturers tend to outsource physical model-making far more than athletic shoe makers. While this can lower fixed labour costs, losing control of the function raises two issues. First, cycle time may suffer, as working with an outside contractor requires a day or two of 'hands-off' time for each iteration. Second, the close communication possible between designer and model-maker in the same office is absent when jobs are sent outside, resulting in lost design intent. Either design quality is compromised or additional iterations are involved, further lengthening cycle times. Finally, outsourcing physical model-making is still expensive. Typical brown shoe sole models cost about $750 each and, at this level, it is claimed that FreeForm run by an in-house model-maker can pay for itself in about 18 weeks based on reduced prototype costs alone.